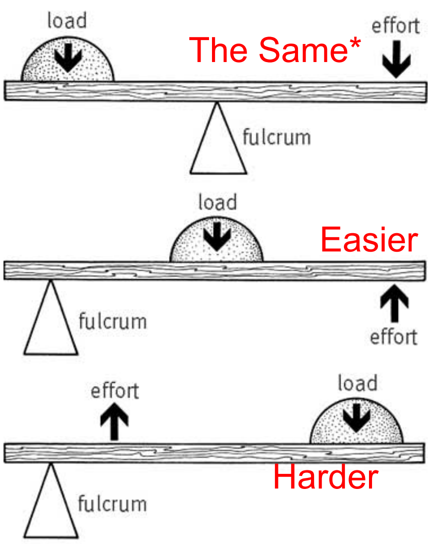
Grade 8 Science

Unit 4: Systems in Action

Levers

Last class we looked at levers, and what can be accomplished by locating the fulcrum in a specific spot. Recall, there are tree classes of lever.



The image to the left shows an example of each of the three classes of lever.

One of the examples would make it easier to lift the load. One of the examples would not provide any advantage. One of the examples would actually make it more difficult to lift the load. Which is which?

*Note: The only reason that the class one lever is "the same" is that the two arms are the same length. This is not always the case.

I need a volunteer to drag these to the proper example.

Mechanical Advantage

When looking at the examples on the previous page we discussed how the effort related to the load, i.e., was it easier, the same, or harder. What we are looking at is called "mechanical advantage."

Mechanical Advantage — A ratio of what is produced by a machine (output) to what is put into the machine (input). For example:

$$Mechanical\ Advantage = \frac{Load}{Effort}$$

Or, simplified, $MA = \frac{F_L}{F_E}$

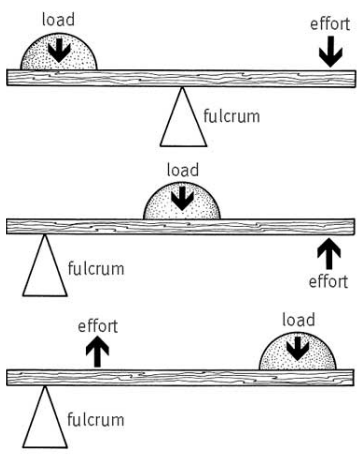
In a previous class we discusses a farmer moving a boulder. The boulder needed 3000 N to move, yet the farmer could only produce 750 N. What was the mechanical advantage of the lever he used?

Mechanical Advantage

We have just defined mechanical advantage as:

$$MA = \frac{F_L}{F_E}$$

On the first page of this lesson we looked at 3 levers, identifying them as making things easier or harder. Using the equation for mechanical advantage, we can define a range of potential mechanical advantage values for each class of lever.



	Potential MA Values
Class 1 Lever:	$MA > 0$
Class 2 Lever:	$MA \geq 1$
Class 3 Lever:	$0 < MA < 1$

Mechanical Advantage

Why is it that some machines would be built that do not provide a mechanical advantage?

Sometimes it is not an increase in force that is desired, but an increase in distance or speed. Take a baseball bat as an example. A bat is a class 3 lever, meaning the effort is in the middle. This means that it has a mechanical advantage of less than one. However, when the bat is swung, the end of the bat is travelling at a much higher speed than the location at which the batter is holding it. This allows the ball to leave the bat at a much higher speed than it would with a class one or two lever.

Mechanical Advantage

When machines are designed, they are designed to produce a certain mechanical advantage. However, in the real world the actual mechanical advantage achieved is less than what was planned. Can you think of why this would be?

The biggest loss is because of friction, meaning that the machine has to overcome more force than it was meant to.

Ideal Mechanical Advantage	A calculated value based on measurements of the machine.
Actual Mechanical Advantage	A measured value based on input and output of the machine.

Using these two values, we can again look at efficiency.

$$Efficiency = \frac{AMA}{IMA}$$

Mechanical Advantage

Levers are not the only simple machine for which we can look at mechanical advantage. There are six simple machines, what are they?

Lever
$$IMA = \frac{Length\ of\ Effort\ Arm}{Length\ of\ Load\ Arm}$$

Inclined Plane
$$IMA = \frac{Length\ of\ Ramp}{Height\ of\ Ramp}$$

Wheel and Axle
$$IMA = \frac{Diameter\ of\ Wheel}{Diameter\ of\ Axle}$$

← Note: "Wheel" refers to the part you turn, "Axle" refers to the part that turns as a result.

Pulley
$$IMA = \frac{Number\ of\ Support\ Ropes}{Number\ of\ Ropes\ Being\ Pulled}$$

Screws and Wedges are special cases of inclined planes.

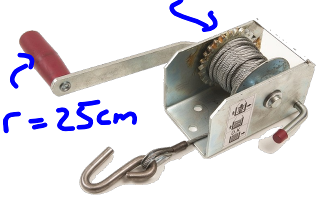
Mechanical Advantage

A winch on a boat trailer has a cylinder that is 4 cm in radius, and it has a crank arm that is 25 cm long. What should be the mechanical advantage of the winch?

$r_W = 25cm$
$r_A = 4\ cm$
$IMA = ?$

$IMA = \frac{r_W}{r_A} = \frac{25}{4} = 6.25$

∴ The mechanical advantage should be 6.25.



If it takes 100 N of force to turn the crank, and the tension in the cable is 600 N, what is the efficiency of the winch?

$F_i = 100N$
$F_o = 600N$
$AMA = ?$

$AMA = \frac{F_o}{F_i} = \frac{600}{100} = 6$

$IMA = 6.25$
$AMA = 6$
$Eff = ?$

$Eff = \frac{AMA}{IMA} = \frac{6}{6.25} = 0.96 = 96\%$

∴ The winch is 96% efficient.